

# Health and Environment Linked for Information Exchange in Atlanta (HELIX-Atlanta)

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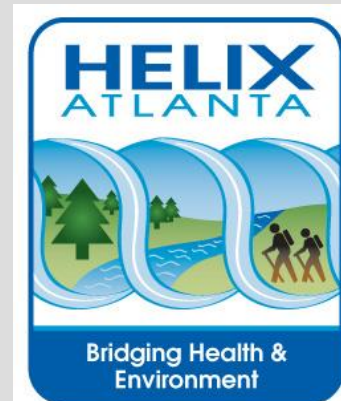
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*ONE step...BEYOND Workshop*  
*European Space Agency/European Space Research Institute*  
*Frascati, Italy, October 15-16, 2015*



# HELIX-Atlanta Overview

- **HELIX-Atlanta was developed to support current and future state and local EPHT programs to implement data linking demonstration projects which could be part of the EPHT Network.**
- **HELIX-Atlanta is a pilot linking project in Atlanta for CDC to learn about the challenges the states will encounter.**
- **NASA/MSFC and the CDC are partners in linking environmental and health data to enhance public health surveillance.**
- **The use of NASA technology creates value – added geospatial products from existing environmental data sources to facilitate public health linkages.**
- **Proving the feasibility of the approach is the main objective**

# HELIX-Atlanta Challenges

- **Sharing data between agencies with different missions and mindsets**
- **Protecting confidentiality of information**
- **Ensuring high quality geocoded data**
- **Ensuring appropriate spatial and temporal resolutions of environmental data**
- **Developing sound resources and methods for conducting data linkages and data analysis**

# HELIX-Atlanta Respiratory Health Team

## RH Team Pilot Data Linkage Project:

Link environmental data related to ground-level PM<sub>2.5</sub> (NASA+EPA) with health data related to asthma

### Goals:

1. Produce and share information on methods useful for integrating and analyzing data on asthma and PM<sub>2.5</sub> for environmental public health surveillance.
2. Generate information and recommendations valuable to sustaining surveillance of asthma with PM<sub>2.5</sub> in the Metro-Atlanta area.

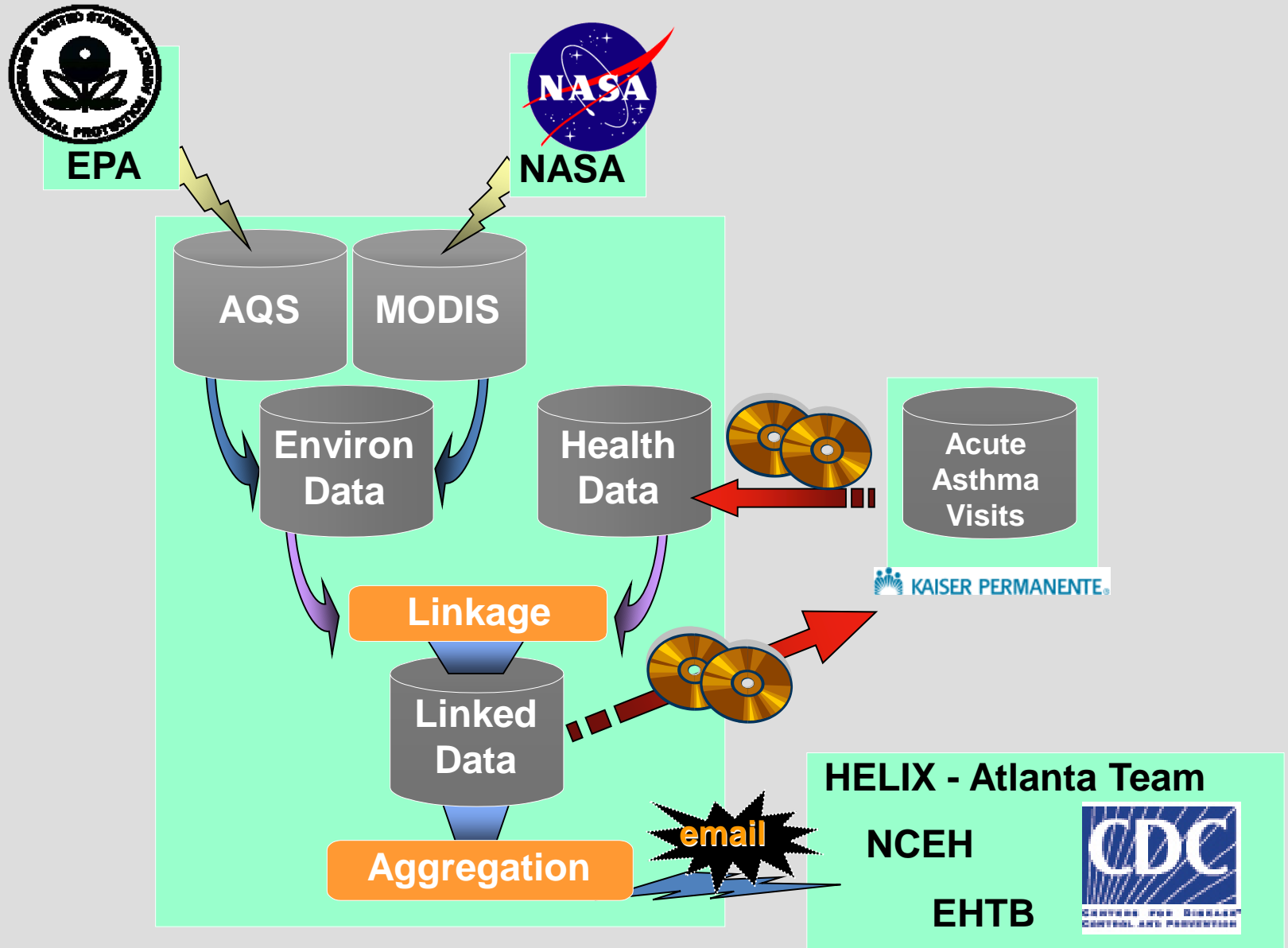
Environmental Hazard Measure: Daily PM<sub>2.5</sub>

Asthma Measure: Daily acute asthma office visits to KP-GA Medical Facilities

Time period: 2001-2003

Linkage Domain: 5-county metropolitan Atlanta

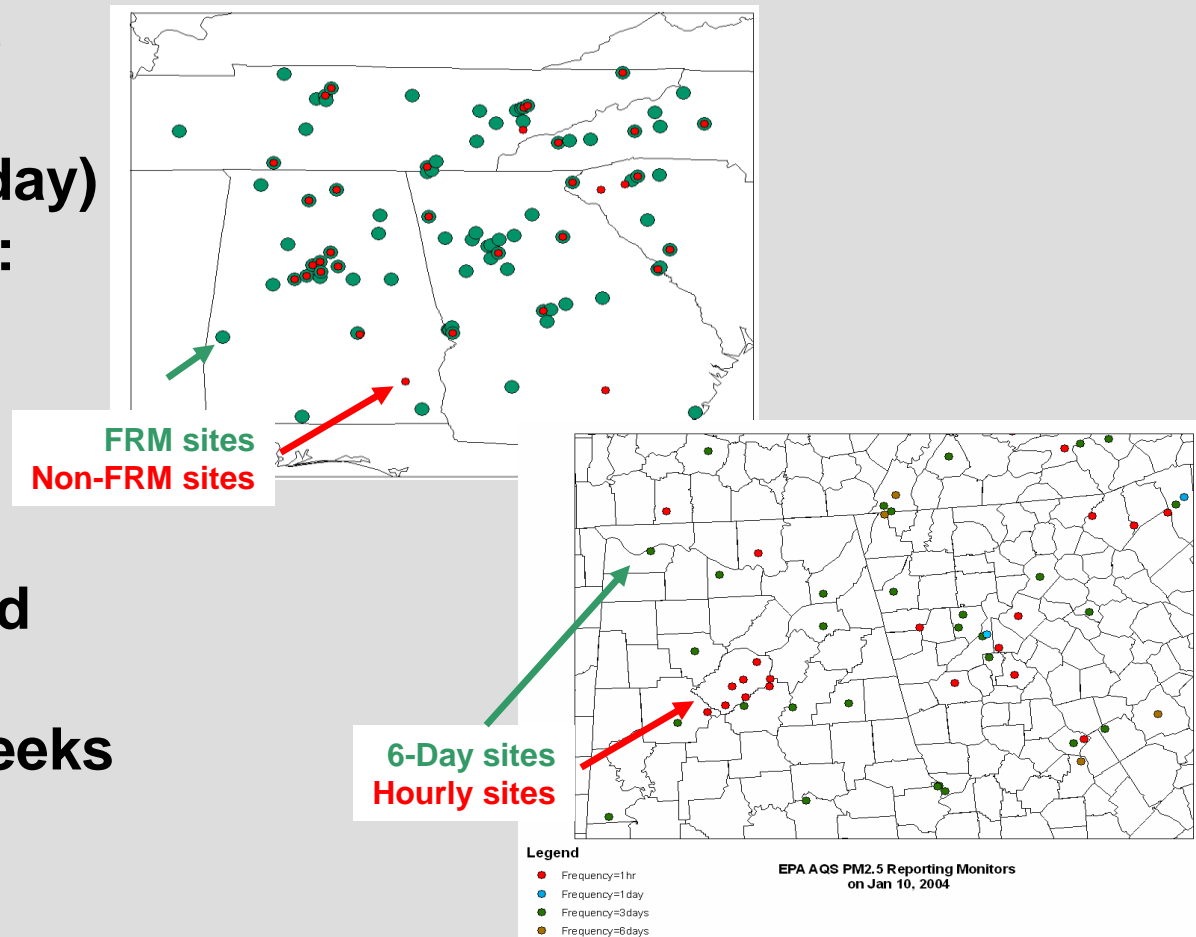
# Data Linkage



# Sources of PM<sub>2.5</sub> data: EPA AQS

## EPA Air Quality System (AQS) ground measurements

- National network of air pollution monitors
- Concentrated in urban areas, fewer monitors in rural areas
- Time intervals range from 1 hr to 6 days (daily meas. every 6<sup>th</sup> day)
- Three monitor types:
  - Federal Reference Method (FRM)
  - Continuous
  - Speciation
- FRM is EPA-accepted standard method; processing time 4-6 weeks



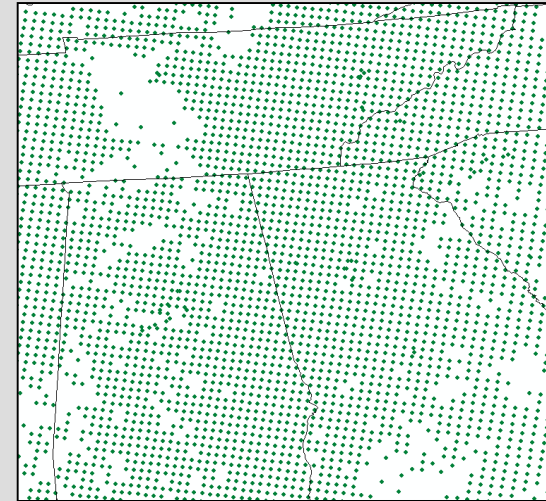
# Sources of PM<sub>2.5</sub> data: MODIS

## MODIS Aerosol Optical Depth (AOD)

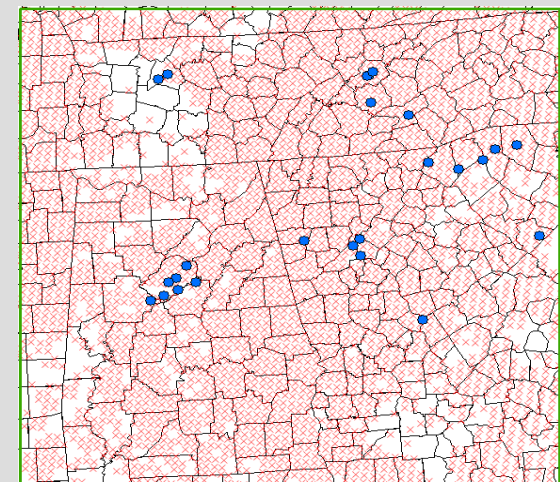
- AOD is a measure of the total particulate in the atmosphere
- If atmosphere is well mixed, AOD is a good indicator of surface PM<sub>2.5</sub>
- Enhanced Spatial Coverage
- Provided on a 10x10 km grid
- Available twice per day (Terra ~10:30 AM, Aqua ~1:30 PM)
- Clear-sky coverage only
- Available since spring 2000



June 25, 2003



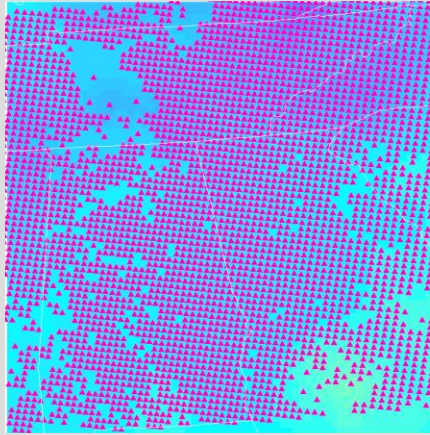
MODIS



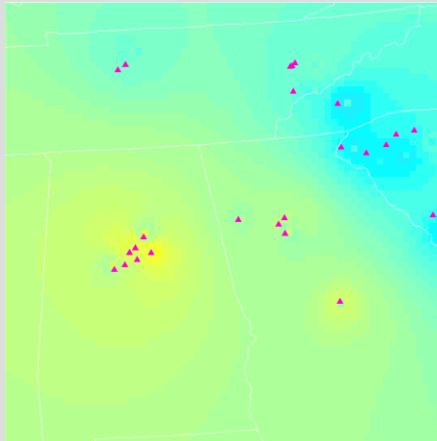
AQS

# Data Merging

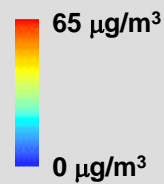
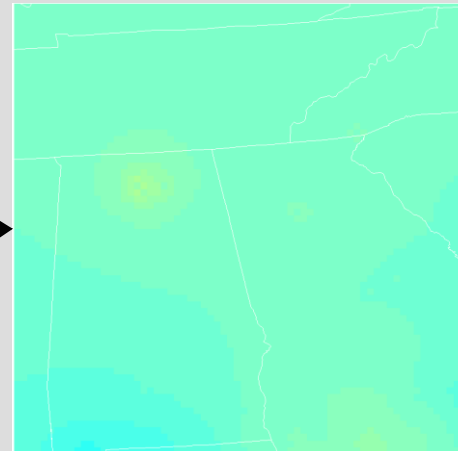
NASA MODIS only



EPA AQS only



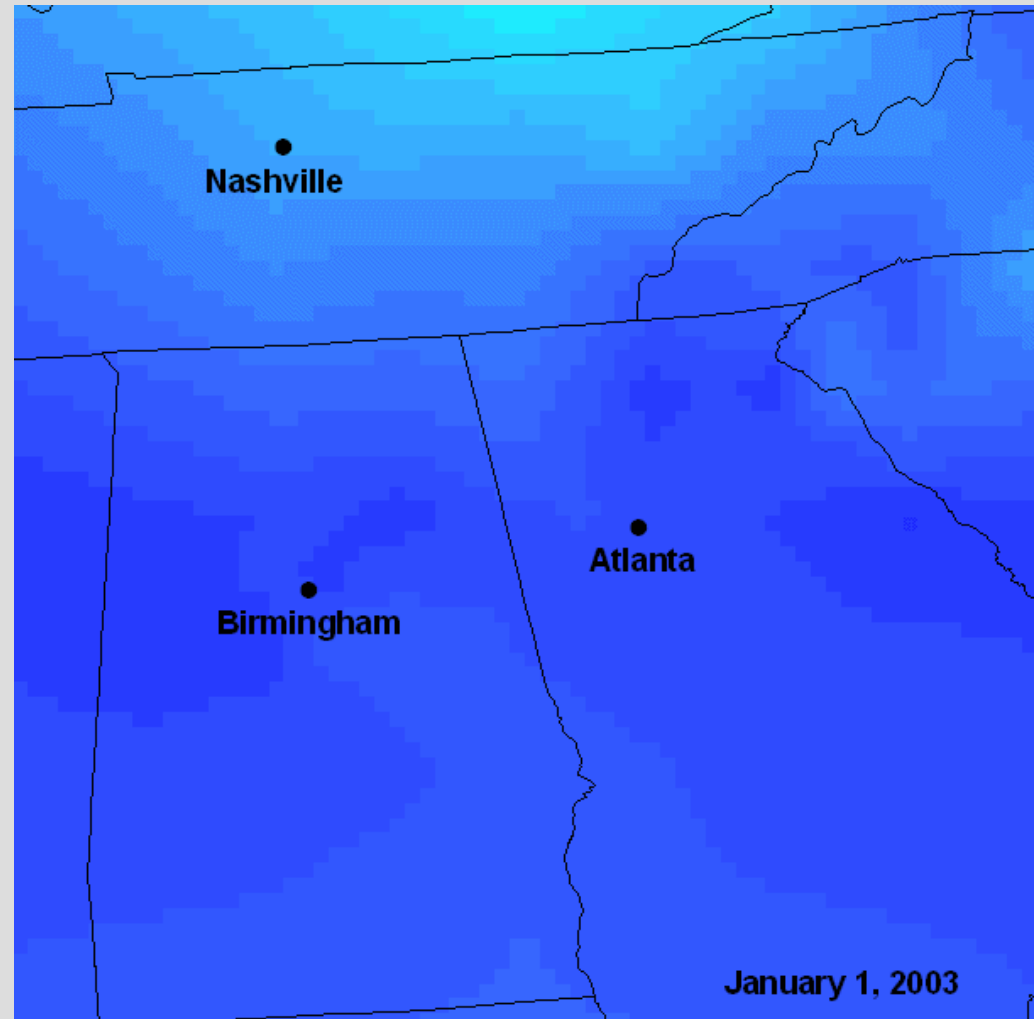
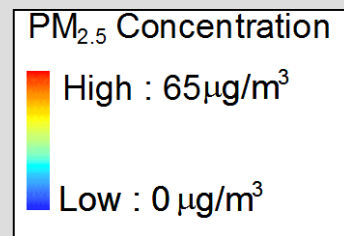
Merged





# PM<sub>2.5</sub> Exposure Assessment- Spatial Surfacing

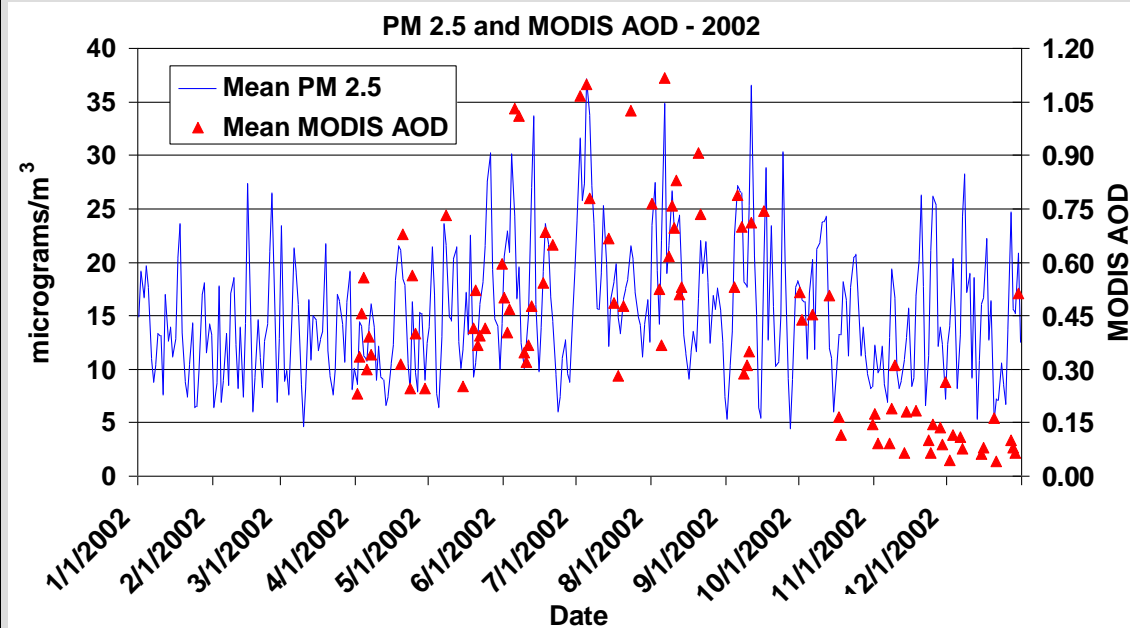
- 1<sup>st</sup> degree recursive B-spline in x- and y-directions
- Inverse Distance Weighted (IDW)
- Daily surfaces created on a 10x10 km grid
- Variable number of measurements available each day



# Estimating PM<sub>2.5</sub> from MODIS data

- For 2000-2003, obtain MODIS AOD and EPA AQS PM<sub>2.5</sub> data
- Extract AOD data for 5 AQS site locations
- Calculate daily averages from hourly AQS PM<sub>2.5</sub> data
- Using daily PM<sub>2.5</sub> averages from all 5 Atlanta AQS sites, determine statistical regression equations between PM<sub>2.5</sub> and MODIS AOD
- Apply regression equations to estimate PM<sub>2.5</sub> for each 10 km grid cell across region

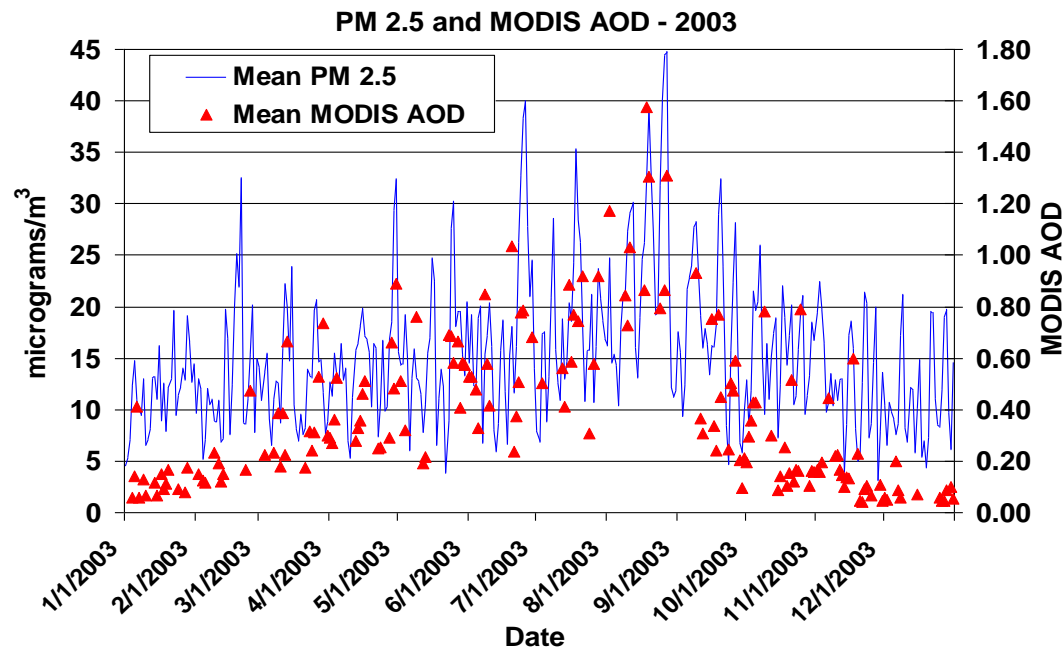
# MODIS AOD - PM<sub>2.5</sub> Relationship



- Daily 5-site means of observed PM<sub>2.5</sub> and MODIS AOD
- MODIS data not available every day due to cloud cover
- MODIS AOD follows seasonal patterns of PM<sub>2.5</sub> but not the day-to-day variability in fall and winter

2002

2003



# PM 2.5 – MODIS AOD Correlations

## April - September

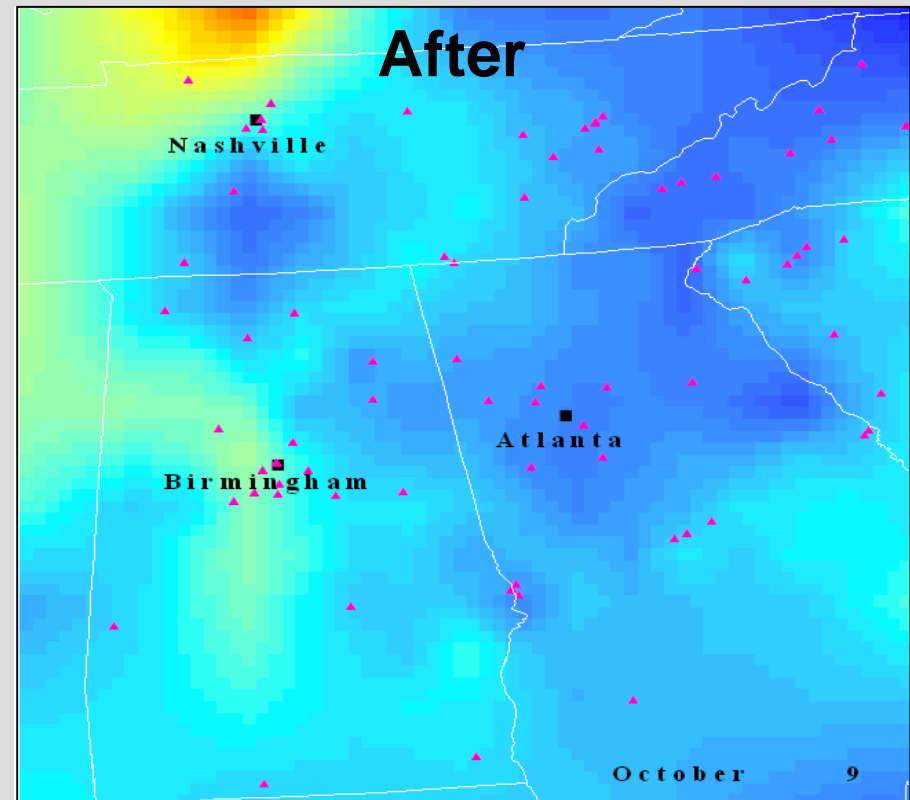
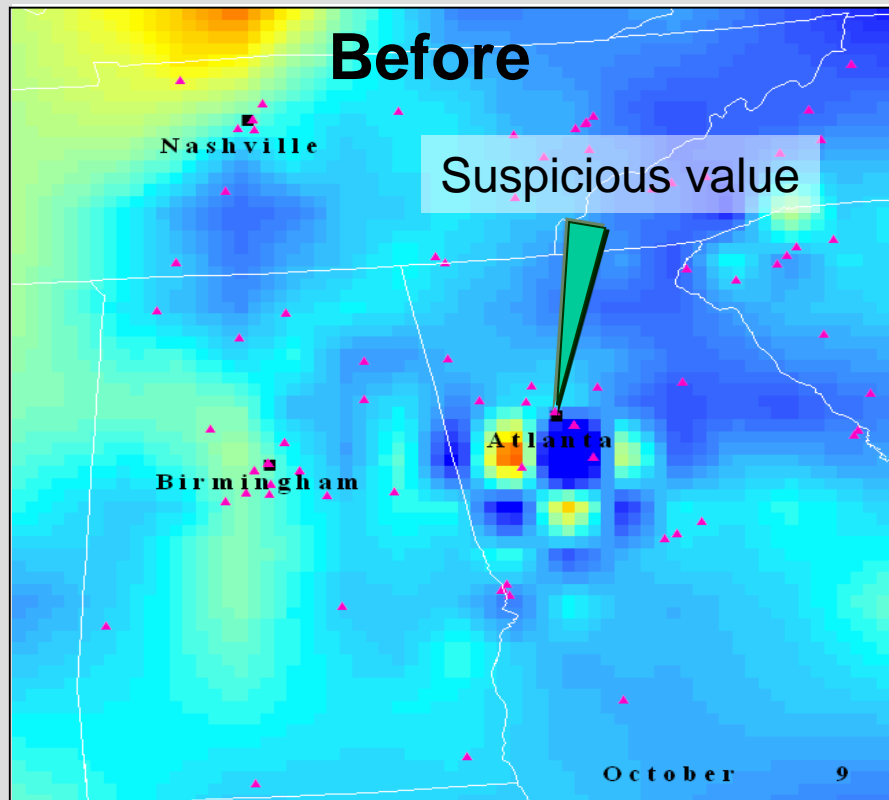
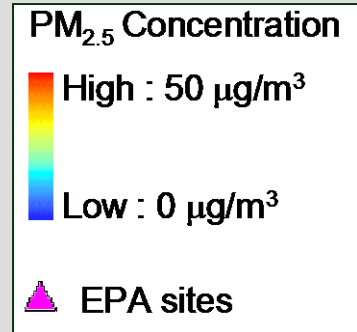
MODIS-Terra    MODIS-Aqua

2000 -->	0.579	
2001 -->	0.643	
2002 -->	0.559	0.401
2003 -->	0.661	0.727

- Correlations between PM<sub>2.5</sub> and MODIS AOD are generally high (> 0.55) for the warm season.
- The lower correlation for MODIS-Aqua in 2002 is for July-September only.

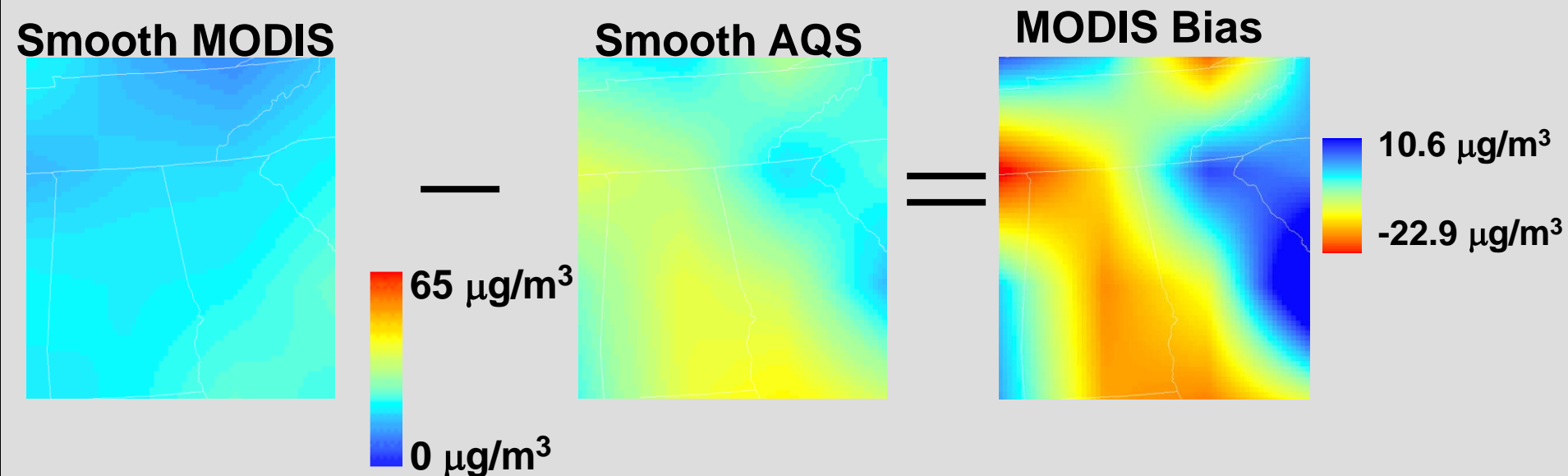
# Quality Control Procedure for AQS PM<sub>2.5</sub> data

- Eliminates anomalous measurements based on a non-parametric rank-order spatial analysis
- Applied to all daily AQS PM<sub>2.5</sub> measurements before spatial surfaces are built



# MODIS PM<sub>2.5</sub> Bias Adjustment

- **Assumption:** AQS measurements are unbiased relative to the local mean, but MODIS PM<sub>2.5</sub> estimates may have biases.
- **Procedure:**
  1. Use a two-step B-spline algorithm to create highly smoothed versions of the MODIS and AQS PM<sub>2.5</sub> daily surface
  2. Compute the 'Bias' as the difference between the smoothed fields
  3. Subtract the bias from the MODIS PM<sub>2.5</sub> daily surface to give the 'bias-corrected' MODIS daily surface

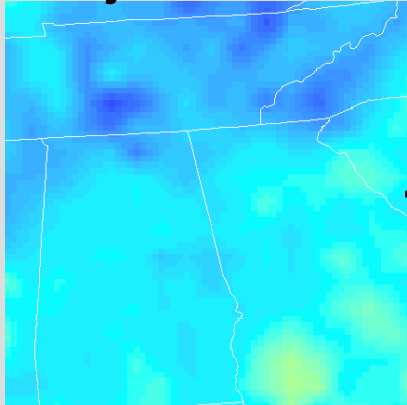


# Merging MODIS and AQS PM<sub>2.5</sub> Data

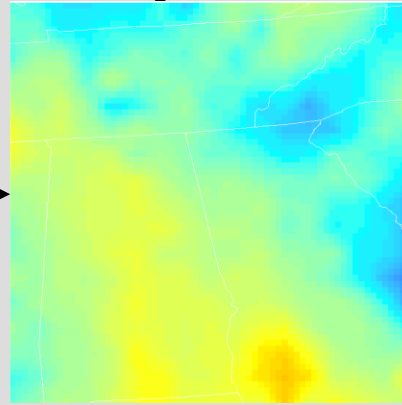
- MODIS and AQS data have been merged to produce final PM<sub>2.5</sub> surfaces.

## B-Spline Surfacing

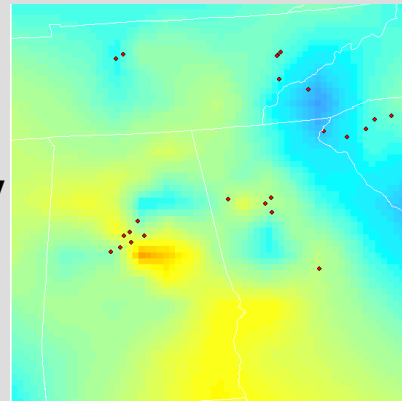
Unadjusted MODIS



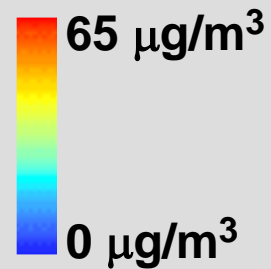
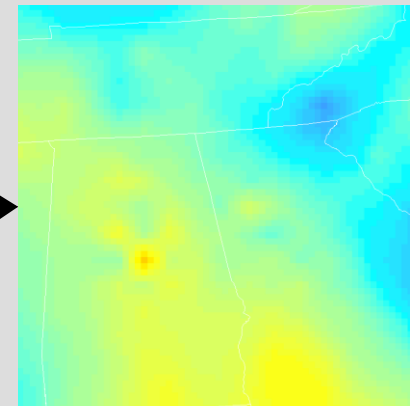
Bias-adjusted MODIS



AQS only



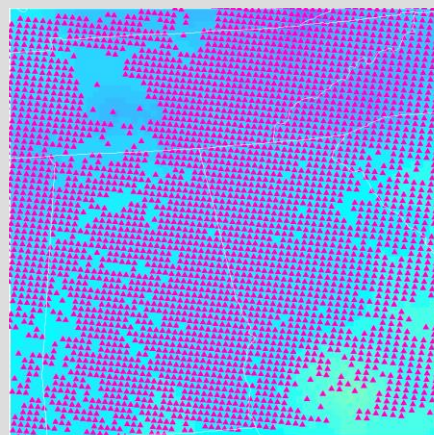
Merged



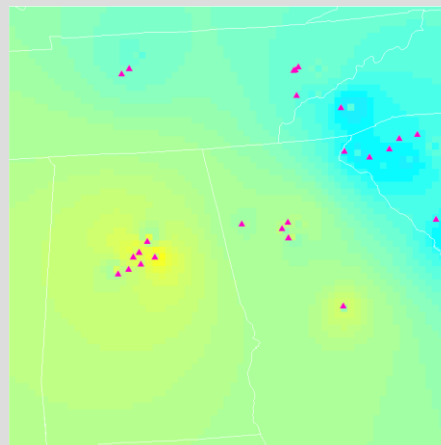
# Merging MODIS and AQS PM<sub>2.5</sub> Data

## IDW Surfacing

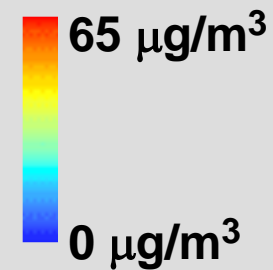
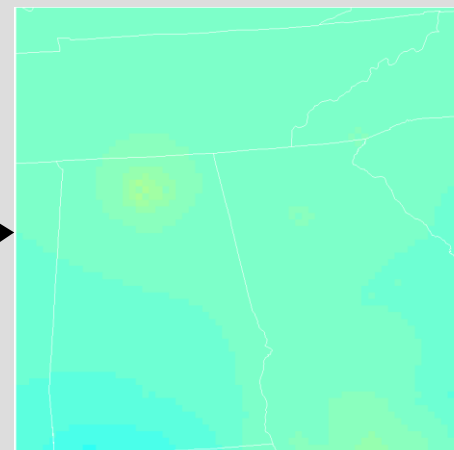
MODIS Only



AQS only



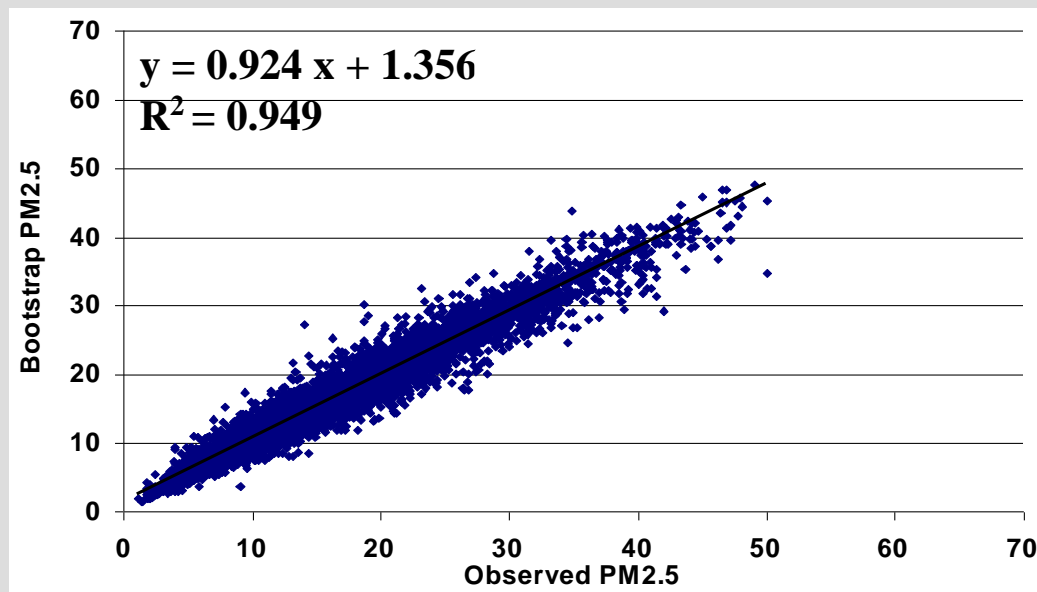
Merged





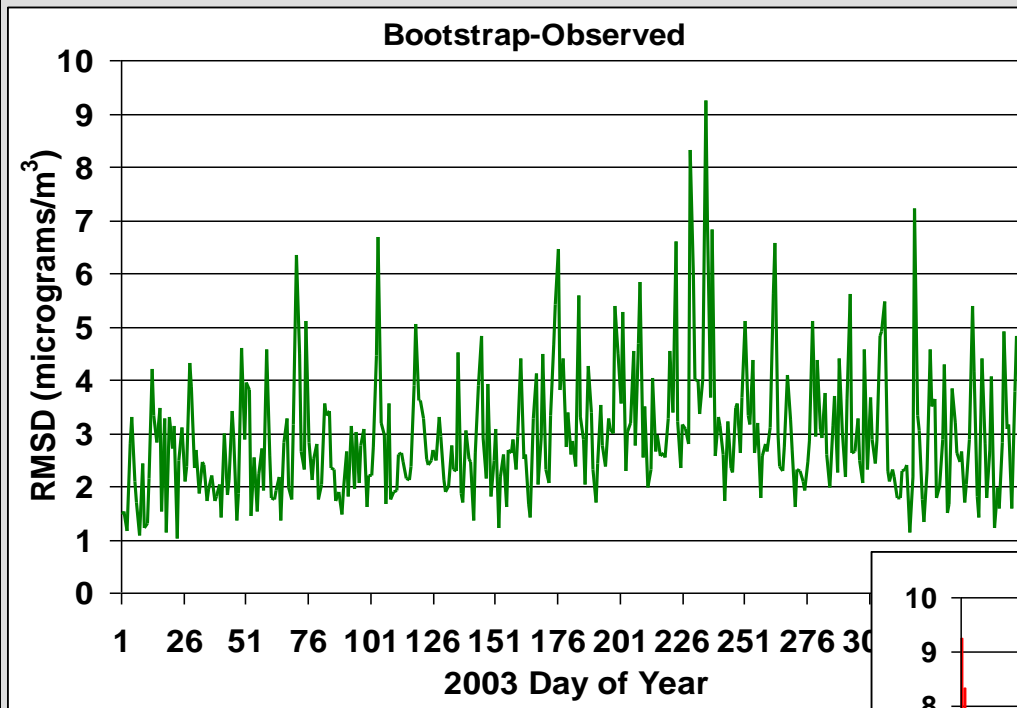
# Cross-Validation

- a.k.a. 'bootstrapping' or 'omit-one' analysis
- **Objective:** Estimate errors associated with daily spatial surfaces
- **Procedure:**
  1. Omitting one observation, create surface using N-1 observations
  2. Compare value of surface at location of omitted observation with the observed value
  3. Repeat for all Observations



# Cross-Validation for B-Spline Surfaces

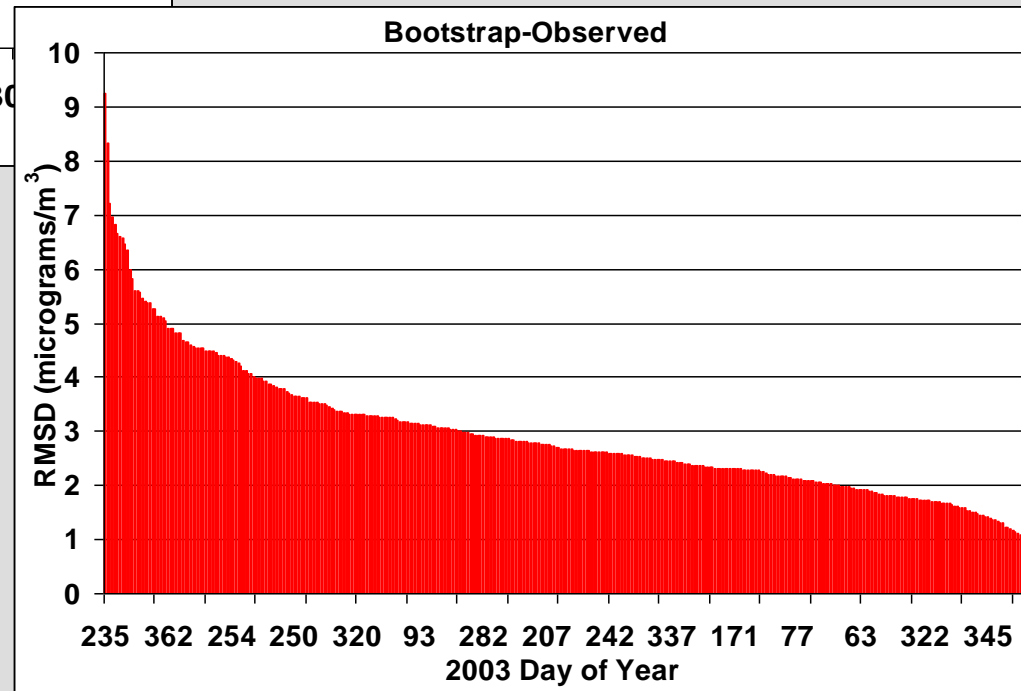
## Daily Error Statistics



**Time Series**

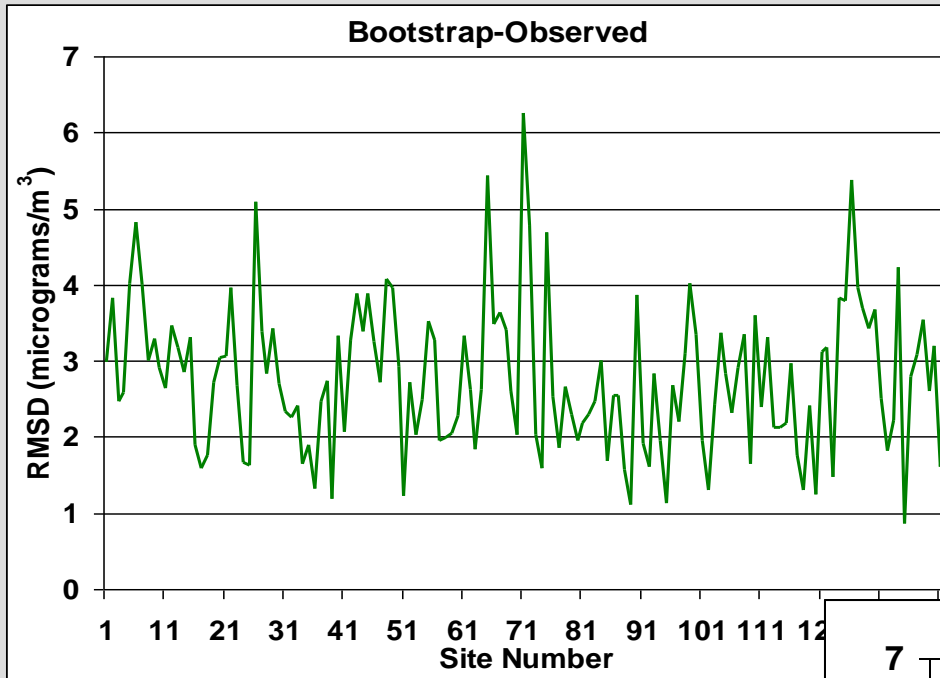
**RMSD =  $2.7 \mu\text{g}/\text{m}^3$**

**Rank Order**



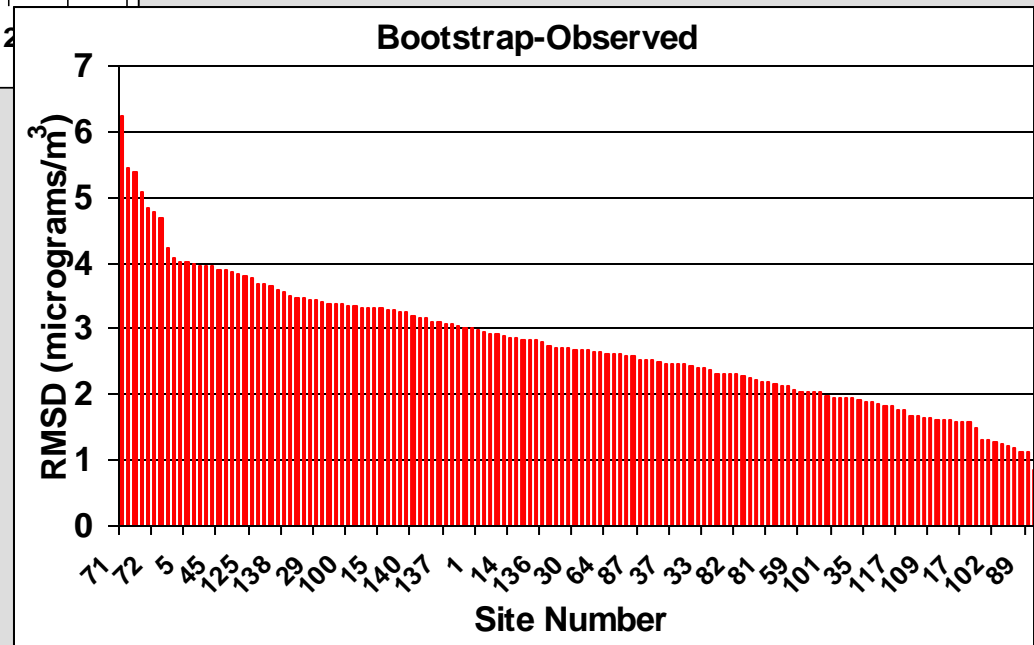
# Cross-Validation for B-Spline Surfaces

## Error Statistics by Site



**RMSD by Site**

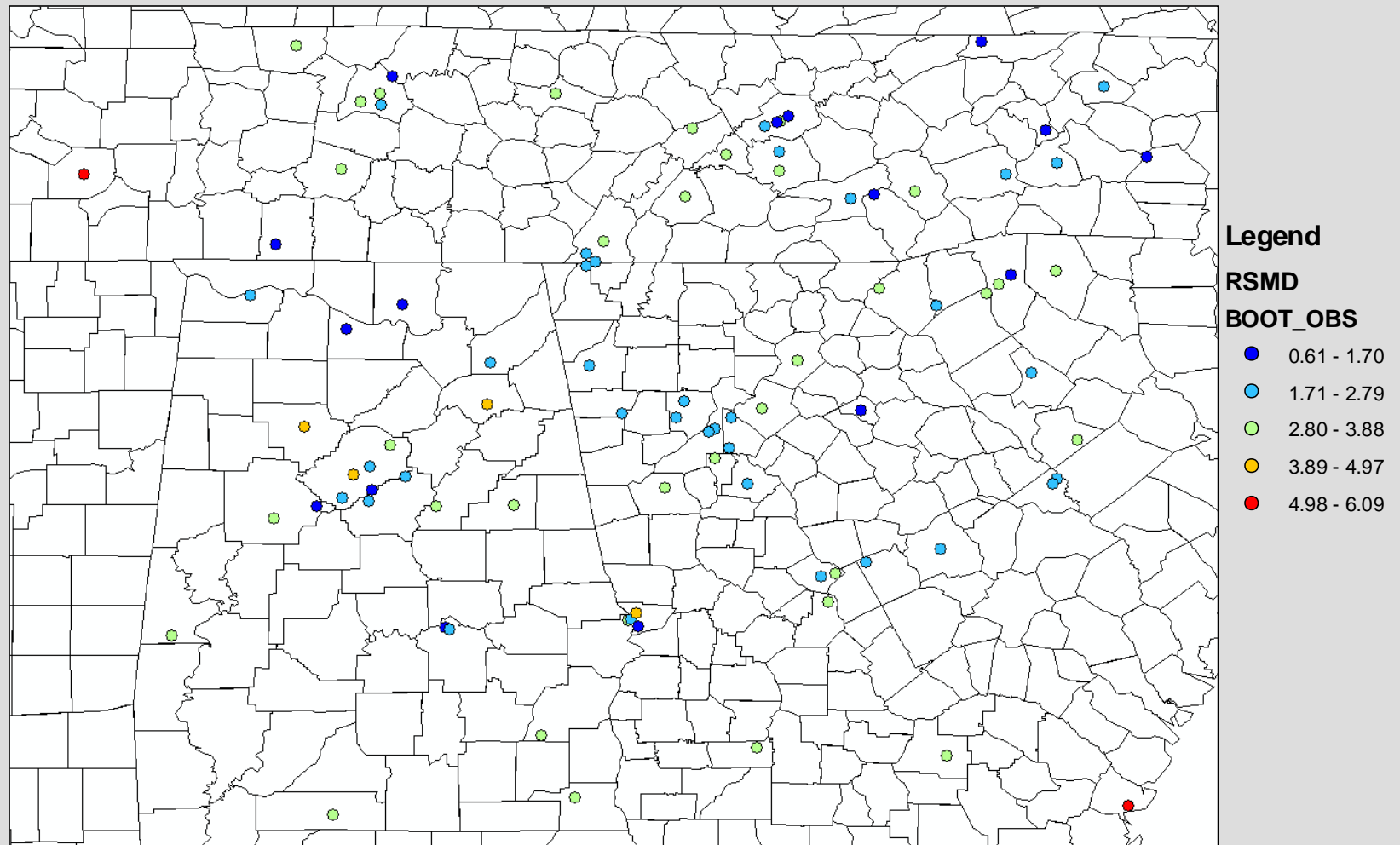
**Rank Order**



# Cross-Validation for B-Spline Surfaces

## Error Statistics by Site

**RMSD by Site**

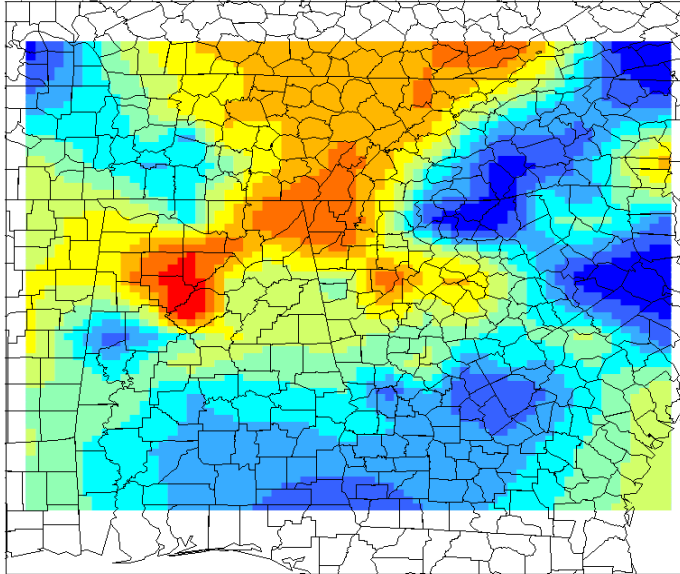


# Surfacing Methods Comparison

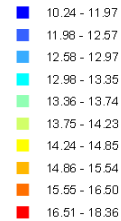
Surfacing Technique	Data Source	RMSD (All Days)	RMSD (Warm Season: April-September)	Improvement
B-Spline	AQS only, no QC	3.30	3.56	
B-Spline	AQS only, with QC	2.93	3.16	12% (than with no QC)
B-Spline	Merged AQS/MODIS	N/A	2.76	16% (than with AQS data only)
IDW	AQS only	2.45	2.69	15% (than B-Spline with AQS)
IDW	Merged AQS/MODIS	N/A	1.61	40% (than with AQS data only)

# Annual Composite Surfaces

PM2.5 B-Spline Surfaces Year 2003 Composite

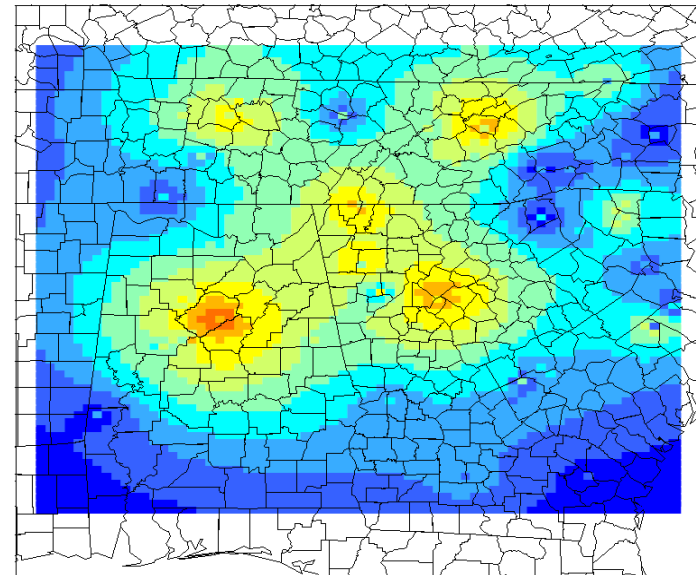


PM2.5 ( $\mu\text{g}/\text{m}^3$ )

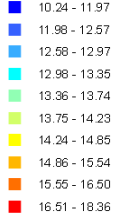


B-Spline

PM2.5 IDW Surfaces Year 2003 Composite

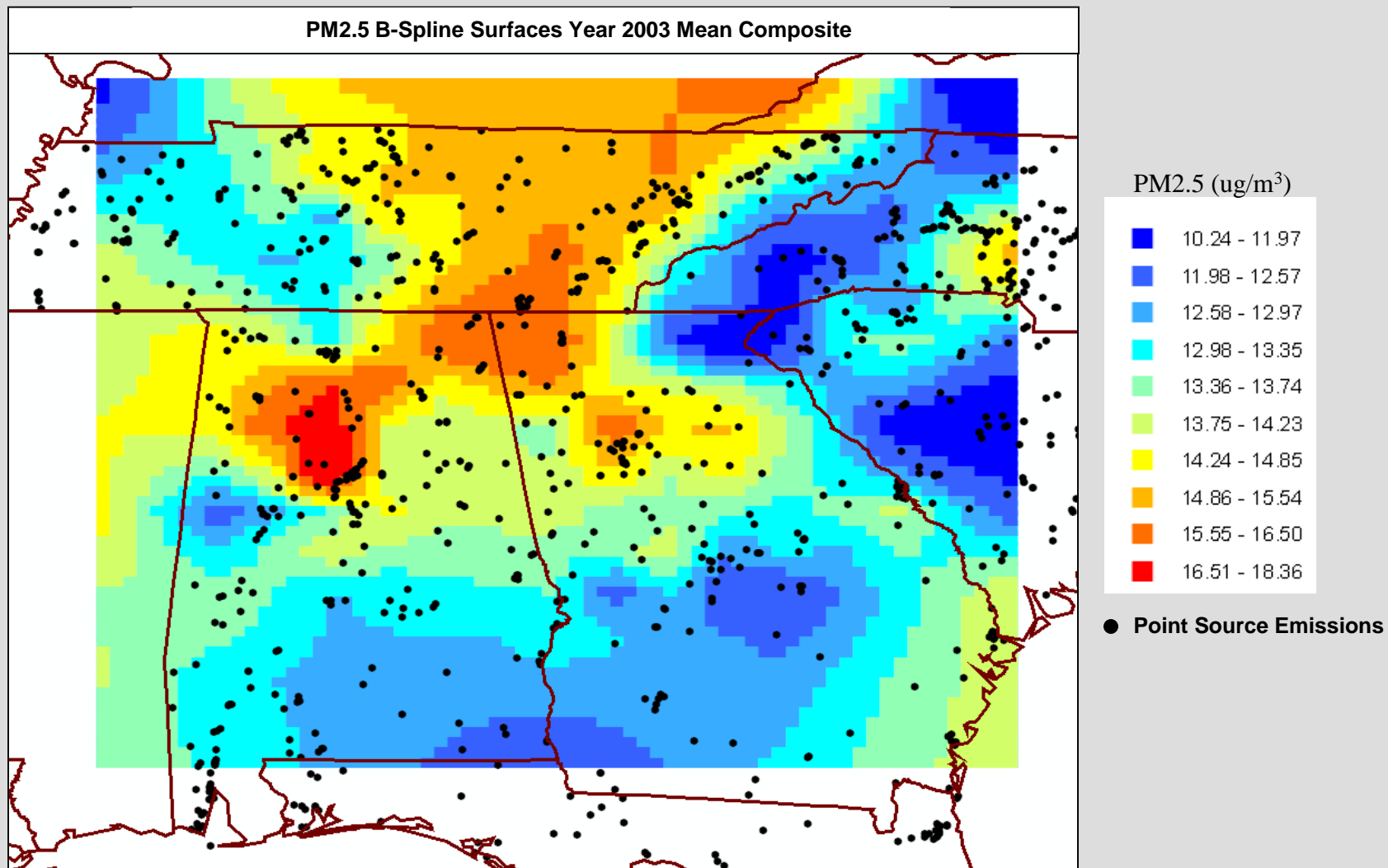


PM2.5 ( $\mu\text{g}/\text{m}^3$ )



IDW

# Point Source Emissions



# Linkage of Environmental and Health Data

## Data Linkage Outputs

### Acute asthma office visit counts by grid cell

Date	Cell	PM2.5	Female Child	Male Child	Female Adult	Male Adult
200301	1	21.74	1	0	2	0
200301	2	12.79	0	0	0	0
200301	3	12.21	0	1	0	1

### PM<sub>2.5</sub> for each visit

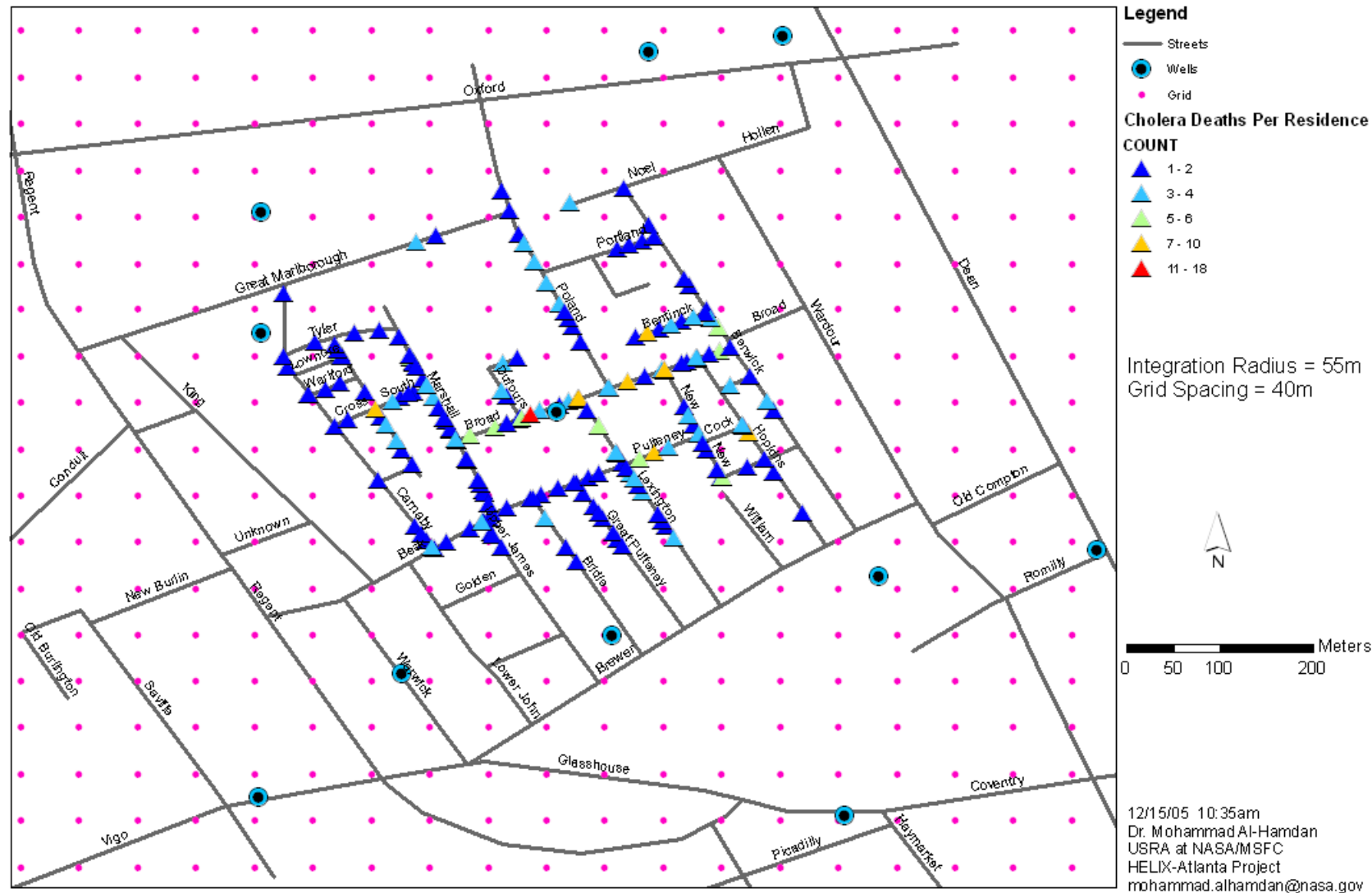
Date	ID	Member	Lat/Lon	Cell	Cell	Lat/Lon	County	State	Gender	Age	PM2.5
200301	1811	99.572	-84.25	1944	99.552	-84.28	Coweta	GA	F	Child	21.74
200302	15299	99.063	-83.86	1608	99.104	-83.81	Upson	GA	F	Child	12.79
200302	15879	99.727	-84.37	2079	99.731	-84.4	Fulton	GA	M	Child	12.21

\*Simulated Data Set. F=female, M=male, A=adult, C=child.



# Public Health Surveillance

## Cholera Deaths Soho, London August-September, 1854

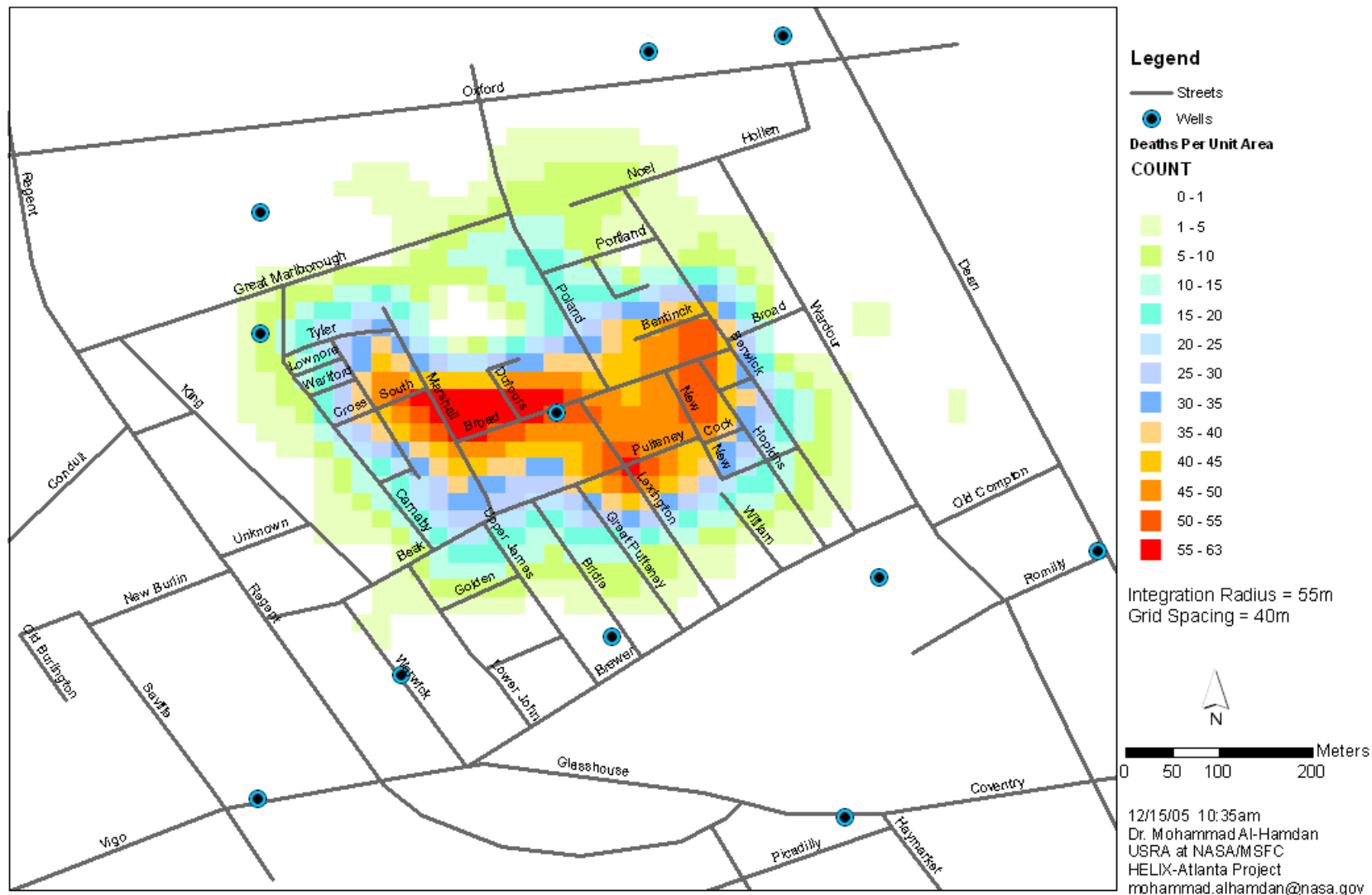


\*Original data were published by C.F. Cheffins, Lith, Southampton Buildings, London, England, 1854 in Snow, John. On the Mode of Communication of Cholera, 2nd Ed, John Churchill, New Burlington Street, London, England, 1855.

\*\*Digital Data of Streets, Wells, and Deaths Residences which were used to create this surface were downloaded from the UCLA Department of Epidemiology Website at <http://www.ph.ucla.edu/epi/snow.html>.

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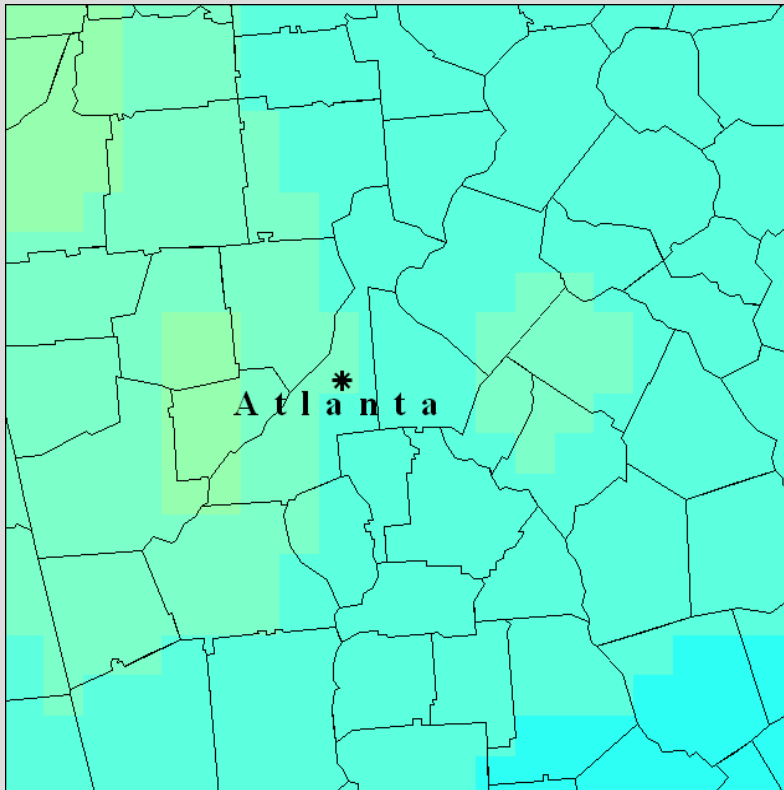
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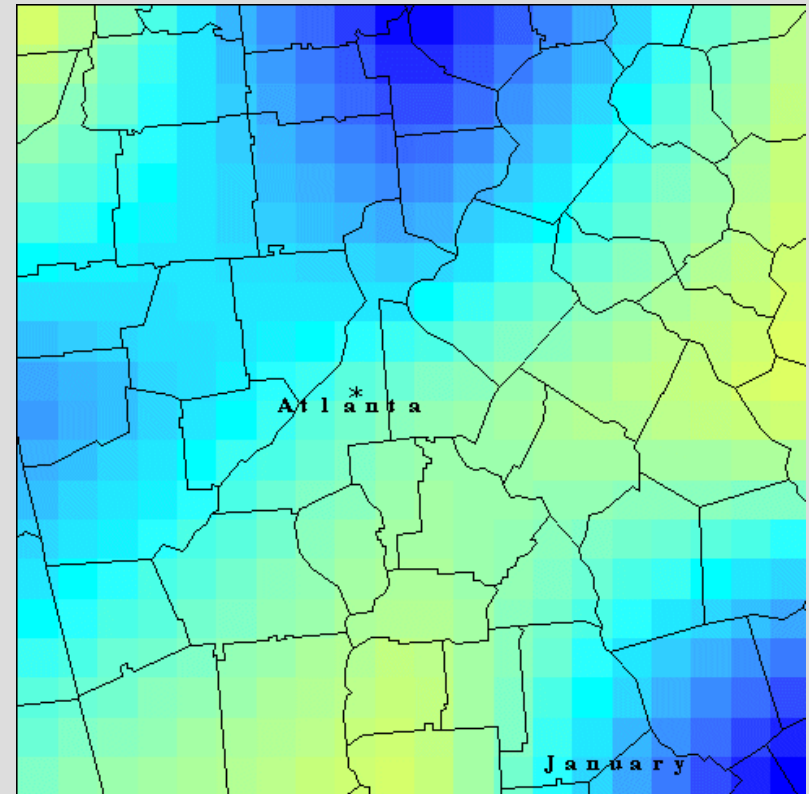
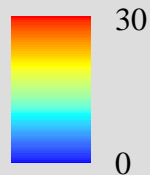


Courtesy: Dr. Jeff Luvall, NASA/MSFC

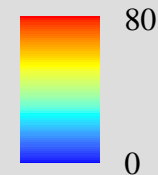
# Public Health Surveillance



Monthly Mean PM<sub>2.5</sub> (ug/m³)



Monthly Asthma Visits Rate (Per 10,000)



**January**

Year 2002



# Successes

- **Proven the feasibility of linking environmental data (MODIS PM<sub>2.5</sub> estimates and AQS) with health data (asthma)**
- **Developed algorithms for QC, bias removal, merging MODIS and AQS PM<sub>2.5</sub> data, and others to incorporate satellite remote sensing into the CDC Environmental Public Health Tracking Network**
- **Developed algorithms for health data surfacing that protects PHI which can be helpful for public health surveillance and decision makers**
- **Negotiated a Business Associate Agreement with a health care provider to enable sharing of Protected Health Information**

# Thanks!

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